Pam: 622.324:621.644 HURD

PROGRESS REPORT ON GAS PIPELINE RESEARCH

by

Mr. Lee HURD

Paper presented

by

Canadian Northern Pipeline Research Conference

Ottawa, Canada

2-4 February, 1972

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THE NORTHWEST PROJECT STUDY GROUP

PROGRESS REPORT ON
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It must by now be an obvious truism that the future of North America's petroleum producing industry will to a very great extent be dependent upon pipelines from the northwest arctic areas of Canada and Alaska.

It has been estimated that investment in pipelines from these arctic regions during the next 10 or 15 years could amount to as much as $10 billion -- a figure which equals the investment in all the railway facilities in Canada.

One of the major pipelines currently envisioned from the arctic is the system being examined by the Northwest Project Study Group -- a 2,400-mile, 48-inch diameter gas line which would cost in the order of $3.5 billion.

The three pipeline participants in NPSG -- TransCanada PipeLines Limited, Michigan Wisconsin Pipe Line Company, and Natural Gas Pipeline Company of America -- began investigations into the feasibility of a pipeline extending into the Northwest Territories in 1967 when gas was found in the southern N.W.T. In 1969, following the discovery of oil and gas at Prudhoe Bay, attention was shifted to the Mackenzie Delta and Alaska North Slope regions. The group was expanded in 1970 by the addition of three producing company participants, which hold the bulk of the gas reserves at Prudhoe Bay -- Humble Oil & Refining Company, Atlantic Richfield Company, and The Standard Oil Company (Ohio).

Under the agreement in mid-1970, the six participating firms committed up to $12 million in expenditures on the study program. Of this amount, some $9 million have now been spent.

It is the intention of Northwest Project participants to perform all of the research and studies which are necessary to demonstrate the feasibility of the project and to support applications to government agencies in Canada and the United States.

Briefly, these studies include:

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ENGINEERING DESIGN & COST STUDIES

The pipeline proposed by our group begins at Prudhoe Bay in Alaska and has its terminus near Emerson, Manitoba, on the United States border. We envision a chilled gas concept whereby, in permafrost areas, the flowing temperature of the gas would be artificially maintained below 32° F., to maintain the integrity of the permafrost. The installed pipeline is to be buried below ground with no berm over the ditch line in almost all locations. Exceptions to this approach may occur at certain river crossings, or in certain soil and slope situations, where above ground construction may be used. The design considerations which follow are consistent with a base case situation, envisioning a 48-inch diameter line approximately 2,500 miles in length, an operating pressure of 1354 psig, and a deliverability potential at Emerson of 3,400 mmcfd. Williams Brothers Canada Limited (Consulting Engineers) have been retained by the Study Group to conduct extensive design, engineering and operational studies, economic and cost studies, research and testing, and other studies related to proving feasibility of the proposed pipeline.

TERRAIN INVESTIGATION & ROUTE SELECTION

In considering a proposed route selection, some of the following points should be included in the analysis:

- The length of the line is of prime economic importance. This consideration may be influenced, of course, by proximity to existing transportation facilities, population centres, undesirable topographical features, access for future construction and maintenance, but by and large is the primary consideration in route selection.
- Economical access to possible future sources of gas, such as occur in the southwest area of the Northwest Territories or in the Mackenzie Delta, also influences the line location.
- Ecological considerations also become extremely important when traversing regions in a delicate ecological balance. In northern latitudes, topography, surface vegetation and soil characteristics are much more influential than in conventional pipelining.

Preliminary route selection was obtained from 1:250,000 scale topographical maps. Having defined a tentative route, both low and high level photography was then obtained along the preliminary route, to supplement existing government photography. Terrain features were then identified as to nature of subsoil occurrences, method of deposition and geological properties from these acquired photographs. Actual on-site coring was used to provide a level of confidence in the terrain typing. This interpretation of surficial geology was then transferred to photo mosaics, which were used for detailed stereoscopic route location. Work on this phase of the design was performed by Dr. Jack Mollard.

PIPELINE DESIGN

The chilled gas concept as envisioned at this time, after exhaustive study of other alternatives, would involve basically conventional pipeline installation techniques. The notable exception would be the use of snow roads as working surfaces during the construction of the pipeline. The chilling facilities at compressor stations are essentially required to remove the heat of compression from the two 20,000 horsepower mainline compressors, plus the heat flow from the ground to the gas. The discharge gas temperature from the compressor station would be controlled to below 32° F. in order not to incur thermal degradation of the permafrost. This would result in flowing temperatures, in northern areas, which approached the temperatures of the surrounding permafrost. In southern areas, the flowing temperature would approach the higher ground temperatures in those areas. In regions of discontinuous permafrost, this flowing temperature would result in the disappearance of small patches of permafrost, thus eliminating the freeze-thaw cycle on the pipeline.

The chilled line, with conventional construction techniques, permits more direct routing as high ice content soils need not be avoided; results in greater efficiency and hence recovers most of the chilling horsepower in increased throughput; and results in considerable construction cost savings.

COMPRESSOR STATION & REFRIGERATION PLANT DESIGN

The base case system proposed will have 44 compressor stations spaced at approximately 50-mile intervals. Two typical compressor stations have

been designed, one operating in the north with transmission temperatures below 32° F., and one for operation in the south with transmission temperatures above 32° F. The main differences in the compressor station designs are reflected in foundation requirements and chilling equipment. The stations will operate remote and unattended, with temporary quarters for maintenance crews. Each compressor station will have its own airstrip, complete with navigational aids. Gas compression equipment proposed at this time consists of two aircraft-type turbine prime movers, driving series connected centrifugal compressors. Each unit will be installed in a separate building to facilitate maintenance. All compressor station piping has been analyzed to ensure that the stress levels occasioned are within the tolerances for the materials specified. The function of the chilling apparatus at compressor stations is to remove the heat of compression, to maintain the gas stream below 32° F. in permafrost areas, and to optimize flowing temperatures in non-permafrost areas. It appears most feasible, at this time, to utilize a propane chilling cycle. A modular concept is proposed for the chilling stations, to adjust the chilling requirement seasonally as well as regionally, maintaining a maximum amount of uniformity in the components. These modules are optimized in size and will utilize turbine drive with centrifugal compressors.

ARCTIC TEST FACILITY

The Arctic Test Facility was designed to confirm that a chilled gas pipeline, constructed and operated in an arctic environment, is technically feasible. Towards this end, the installed facilities at Sans Sault, on the Mackenzie River, were constructed and are operated in the manner which most closely approximates actual installation and operating conditions. Extrapolation of these test results and operating data, combined with the theoretically computed design and operating criteria, will provide a high level of confidence in the ultimate system design.

The site selected for the Test Facility was chosen for a number of reasons. Diverse soil types, which would be representative of a large portion of the proposed pipeline route, were required within a relatively small area. Discontinuous permafrost was required to allow observation of soil types where the effects of the pipeline on permafrost degradation

would be most pronounced. Accessibility by air and water was also a prime consideration, as was a nearby gravel source. The test site selected satisfies all of the above requirements.

Two major types of pipeline installations are included in the testing program: active and inactive sections. The active sections, which provide the majority of research information, are full-scale pipeline loops using air as the flowing medium. The inactive sections simulate pipeline conditions between the completion of construction and the beginning of operations. The cold loop of the active section consists of three buried test sections, operating at various flowing temperatures below freezing. The cycling portion of the active section is comprised of one buried and one elevated section, which may be operated in either a chilled or heated mode. The construction of the sections enabled re-vegetation research to be established under conditions exactly simulating the actual construction of a pipeline.

PROJECT GEOMET

Remote monitoring Geomet stations have been installed at various locations along the proposed pipeline route. The principal purposes of the program are to determine the significant factors controlling permafrost temperatures; to develop quantitative data for the prediction of permafrost conditions; to develop temperature criteria for the design of chilling stations, foundations, pipeline specifications, etc.; and to establish a soil temperature data bank for use in operation of the system.

The information regarding the temperature of the top twenty feet of soil and the ambient conditions is automatically recorded at each Geomet station. The unattended period of operation is in the order of six months.

ENVIRONMENTAL PROGRAM

The purpose of the environmental studies is to define any possible areas where construction and operation of the pipeline might conflict with the wildlife resources, and establish ways to avoid or minimize such conflict. The approach of the Northwest Project is to do all studies required to ensure that the effects of any such conflicts are minimized. Also included in the environmental program are vegetation studies to find means to establish

suitable restoration of a vegetation cover over a buried pipeline, in order to avoid thermal erosion of the underlying permafrost in the vicinity of the pipeline and spoil bank, and arrest alluvial erosion. Consideration is also being given to proposals concerning archaeological problems along the proposed right-of-way. A program is proposed that would be established to conduct all archaeological salvage in the right-of-ways of a northern gas pipeline. The environmental studies are being conducted largely by outside consultants, whose activities are coordinated by Williams Brothers Canada Limited in Calgary.

CARIBOU STUDY

The broad objective of the caribou study is to determine the impact that construction and operation of an underground gas pipeline would have on Yukon caribou populations. Implicit in the objective is the need to identify potential conflicts and to recommend means of avoiding damage to the caribou population. The specific objectives listed below are biological in orientation and concerned with providing baseline information necessary to meet the requirements of the broad study objective.

- To determine the population size and dynamics for the total migratory caribou population of the northern Yukon.
- To delineate winter ranges and calving grounds of the migratory caribou population of the northern Yukon.
- To determine migratory routes used by the above caribou, the timing of migration and numbers of animals using the various migratory routes.
- To investigate factors influencing migration, including ecological factors, human activity such as compressor stations, and alterations of the landscape such as pipeline right-of-way.

Conducted by a field party of three biologists from a base established at Old Crow, a Yukon village 25 miles east of Alaska, the caribou survey began in mid-March, 1971. The field party is backed up by Ron Jakimchuk, president of Renewable Resources Consulting Services Ltd. in Edmonton. Participating with Renewable Resources as an advisor in the planning and supervision is Dr. Frank Banfield of Brock University, St. Catharines, Ontario, former director of the National Museum of Natural Sciences in Ottawa, and a leading authority on caribou.

FURBEARERS

In addition to the caribou studies, Renewable Resources Consulting Services and Dr. Banfield are conducting studies of furbearing animals. A wide range of animal species are encompassed by the general term "furbearers." These include marten, arctic fox, red fox, fisher, weasels, bears, beaver, muskrat, mink, lynx, otter, wolverine and wolves. The scope of the field studies has been narrowed from the total species list to include those species which are most significant from a trapping or ecological viewpoint, and those which may be most affected by pipeline construction and operation. These species are: arctic fox, barren ground grizzly, beaver, muskrat, wolves. The study also deals indirectly with mink and marten.

Since the proposed north slope route passes through the areas of importance to barren ground grizzly bears and arctic fox, the emphasis has been placed on these species in the north slope studies. The proposed route also crosses several important areas for beaver and muskrat and, as a result of the importance of these areas to the trapping economy, studies are oriented towards ascertaining the impact a pipeline will have on beaver and muskrat habitats.

ICHTHYOLOGY

The main objectives of the fish study are to ascertain the fisheries resources of major streams and rivers which may be crossed by the pipeline, and to evaluate the impact of construction activities on this resource. From this information, recommendations will be made suggesting methods to minimize the disturbance.

No studies of a survey nature are planned, as this information is being gathered by governmental agencies. The approach, which will utilize this information, is to determine the life history of specific streams in great detail, and to extrapolate the data over the proposed route. Almost no data is known on the life history of fish populations in the arctic and mid-arctic drainages. By determination of the migratory habits, over wintering areas, spawning grounds, invertebrate concentrations, etc., the timing and location of pipeline construction may be assessed.

Detailed life history studies in the three major drainages are planned. The locations are on the Firth River for the north slope drainage, the Old Crow or Bell River for the Porcupine drainage, and on the Donnelly River for the Mackenzie drainage. Synoptic studies of all major streams and rivers will be conducted to ensure valid extrapolation of the study results.

The planning and supervision of the program was by Dr. Peter J. McCart of the University of Calgary. Dr. McCart also supervised the fisheries research in Alaska for the Alyeska Pipeline Service Company.

ORNITHOLOGY

Consultants for the ornithological study are LGL Limited, Environmental Research Associates, of Toronto, the principals being Dr. Bill Gunn, Aird Lewis and John Livingston. The field staff was under the direction of Dr. Ray Schweinsburg and consisted of a four-man field crew of biologists and zoologists.

Because of their North American economic significance, particular attention is being given to waterfowl; that is, ducks, geese and swans. For survey purposes, three critical areas have been defined: Prudhoe Bay to Mackenzie Delta, Donnelly River to Trout River, and Athabasca to Cold Lake area. In the first survey area, special emphasis has been placed on Old Crow flats, lower Rat River and the Malcolm and Firth River systems. In these areas the location and extent of bird concentrations have been determined during spring migration, breeding and nesting, moult, and fall assembly prior to migration.

Standard aerial survey methods were used to estimate population sizes and define habitat locations. Ground transects were established at many locations which were walked at intervals to determine accurate base line data. These transects will be checked in the future to determine if any change has occurred from the established base.

Experimental work is planned to evaluate the tolerance of birds to aircraft disturbance, human presence and simulated industrial noise. These experiments will be monitored at different times during the year.

Some survey work will continue in northern Alberta to determine if the proposed route approaches locations of endangered species, i.e., any

new whooping crane nesting areas, pelican colonies, etc. Work on endangered species in the Mackenzie Valley has been minimized due to the efforts of the Wildlife Service in this area.

VEGETATION RESTORATION

The vegetation research program is being viewed in two phases. The first phase is a temporary vegetative cover to retain surface stability and retard thermal degradation due to the disturbance caused by pipeline construction activities. The second phase is the reinvasion of the naturally occurring species to re-establish the former plant community. Studies have been completed-examining seismic lines where the vegetation was cleared some years ago. Observations were made of the plants belonging to the former black spruce - muskeg community that have survived the clearing of the line and the growth response of the plants recorded in the severely altered habitat. At the test site, observations were made before and after construction of the cold and cycling loops to ascertain the amount of damage to the tundra occasioned by construction on a winter road surface.

Four of the buried pipeline sections at the Test Facility were seeded with eighteen species of grasses. Different fertilizer rates were applied in the test plots and comparative measurements have been recorded during the summer. Three of the critical areas being investigated are dry ridges, river banks and side slopes. These plants are being considered as initial binding agents. Specific critical areas have been seeded with willow and alder cuttings to establish shrub cover to bind the deeper soils on these critical slopes. Various types of native grass seeds have been used to evaluate the effectiveness of these species. They are considered to be most valuable in that they require less nutrients and have a natural persistence.

Consultants and advisors, respectively, to the vegetation restoration program are Dr. R. G. H. Cormack of Edmonton and Dr. Stan Rowe of Saskatoon.

GAS RESERVE STUDIES

The firm of DeGolyer and MacNaughton, petroleum engineering and geological consultants, were retained during mid-1970 to investigate and report on the estimated present and potential gas reserves on the North

Slope of Alaska, the Yukon and Northwest Territories, and the Provinces of British Columbia, Alberta, Saskatchewan, and Manitoba, adjacent to or in the vicinity of the proposed route of the Northwest Project pipeline. This study is under way and will be available for inclusion in the applications to the various regulatory agencies for construction of the line.

This assignment requires a detailed investigation of all information that has been developed by the exploration and drilling efforts of the oil and gas industry within the study area. It should be noted that excellent cooperation has been received from the industry in making these data available for the use of our consultants. These data include certain information being held confidential by the respective companies as well as other pertinent information that has not been released or made available publicly. In addition, an investigation is required of all information developed and published by the various Canadian geological societies and regulatory agencies of Canada including the Geological Survey of Canada.

Many of the areas in the study area are undergoing active exploration and our consultants are maintaining up-to-date records on all activity and will adjust reserve estimates as necessary prior to filing of the final report. It is anticipated that the 1971-72 winter exploration effort of the industry will result in the development of substantial hydrocarbon reserves.

CONSTRUCTION AND LOGISTICS

Winter pipe line construction techniques have been used in northern Alberta and British Columbia for several years. Studies are underway to investigate adaptations and revisions that would be required for construction in more northern areas up to and including the arctic coast. Included are determinations of the lighting requirements during the period of continual darkness, the design of shelters for some of the construction operations to control the working environment and the redesign that might be necessary for some of the construction machines that will be working in permafrost.

Substantial quantities of construction equipment and supplies and permanent materials required for the pipe line will have to be moved into the north over a relatively short period of time. Detailed logistic studies

underway to determine the capability of all the existing transportation tems and the expansion that will be necessary to handle this large amount traffic. Numerous staging areas have been selected along the Mackenzie er to accommodate materials and equipment that could be moved by barge. dies are well advanced that will determine the types and amounts of erials and equipment that could be best moved by utilizing winter roads l the Dempster Highway, now under construction.

RTHERN RESIDENTS

The Northwest Project Study Group has recently retained the Boreal stitute for Northern Studies, a research institute located at the University Alberta, Edmonton. The Institute will perform studies and design a program r recruiting and training Northerners for permanent employment in operating d maintenance positions on the pipeline.

Input to the study will include:

-- The operations and maintenance plan prepared by NPSG, which describes the number and the qualifications of permanent employees.

-- The census and other statistical data available to the Boreal Institute from its own files and from data gathered and reported by the Department of Indian Affairs and Northern Development.

-- Advice and comment at two or three month intervals from an Advisory Board of northern people. Board members will be recruited and the Board chaired by Mr. N. Sibbeston of Fort Simpson, N.W.T.

The plan developed by the Boreal Institute will provide answers to such uestions as: what opportunities are there in construction work on the pipeline obtain training which will help qualify Northerners for permanent operations nd maintenance positions on the pipeline; how early should training be started or each of the job categories which can be filled by Northerners; what are the est locations for training centres; etc.?

It is the policy of NPSG to make the maximum practical use of ortherners during the research and study phase of its work. Throughout he construction of the Sans Sault Test Facility about one half of the ontractor's crew was recruited from Fort Good Hope and other northern

settlements. About four were retained through the summer to perform maintenance work.

In addition, almost all of the wildlife consultants' field crews include, at our specific request, as many northern people as practical. An additional four were provided employment in this manner.

All of our experience to date in employment of Northerners has been gratifying to us.

Date Due

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AUTHOR
HURD, Lee

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